<Advanced Research Center for Beam Science> Particle Beam Science

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- Particle Beam Science -

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Visitors

Dr SMIRNOV, Alexander V	Joint Institute for Nuclear Research, Russia, 21 January–11 February 2006
Prof MESHKOV, Igor N	Joint Institute for Nuclear Research, Russia, 4–10 June 2006
Dr DIETRICH, Jürgen	Forschungszentrum Jülich, Germany, 4–10 June 2006
Prof SESSLER, Andrew M	Lawrence Berkeley National Laboratory, USA, 1 November 2006
Prof SHEVELKO, Viatcheslav P	P. N. Lebedev Physical Institute, Russia, 20 November 2006

Scope of Research

The following subjects are being studied: Beam dynamics related to space charge force in accelerators: Beam handling during the injection and extraction processes of the accelerator ring: Electron cooling of a hot proton beam; Compression of the energy spread of laser produced ion beams by an rf cavity for phase rotation; Research and development of permanent quadrupole magnets for final focusing of International Linear Collider (ILC); Generation of ultra-cold ion beams by electron and laser coolings; Mitigation of power loss due to skin effect.

Research Activities (Year 2006)

Presentations

Experimental Strategy for Realization of 3-D Beam Ordering with Use of Tapered Cooling at S-LSR, Noda A, Invited Talk at 39th ICFA Advanced Beam Dynamics Workshop, High Intensity High Brightness Hadron Beams, 31 May.

Commissioning of Electron Beam Cooling at S-LSR, Shirai T, 39th ICFA Advanced Beam Dynamics Workshop on High Intensity High Brightness Hadron Beams, 31 May.

High-energy High Frequency Buncher, Iwashita Y, 7th International Workshop on Neutrino Factories & Superbeams, 28 August.

Limits of RF Deflectors, Iwashita Y, Workshop on "ILC Small Crossing-angle Interaction Region", 19 October.

Permanent Magnets, Iwashita Y, Workshop on "ILC Small Crossing-angle Interaction Region", 20 October.

Grants

Noda A, Beam Accumulation and Cooler Ring, Advanced Compact Accelerator Research Project, Ministry of Education, Culture, Sports, Science and Technology, 1 April 2001–31 March 2006.

Iwashita Y, Super Strong Permanent Magnet for Final Focus Lens in Linear Collider, Grant-in-Aid for Scientific Research, (A) (1), 1 April 2002–31 March 2006.

Shirai T, High Energy Electron Extraction from Electron Storage Ring, Grant-in-Aid for Scientific Research, (C) (2), 1 April 2004–31 March 2006.

Beam Ordering of 7 MeV Protons at S-LSR

Charged particle beams are usually in the gas phase. Each particle has a large kinetic (thermal) energy in the particle rest frame. When the gas is cooled, it transfers to the liquid or solid state. When the charged particle beam is cooled, it is also predicted to move to the ordered state by phase transition. In the experimental studies, one dimensional transitions of the highly charged ions were found at GSI and MSI but it was not yet found for the single charged ions.

We carried out the electron cooling experiment of 7 MeV protons with the ion storage ring, S-LSR at ICR. The proton beam was cooled by electrons, which moved along protons in parallel and removed the thermal energy through a Coulomb interaction (see Figure 1). The result is shown in Figure 2 [1]. When the stored particle number was reduced, the space charge heating became weak and the momentum spread $\left(\propto \sqrt{T_{//}}\right)$ was decreased. Around the particle number of a few thousands, the momentum spread dropped abruptly, which showed that the beam phase was changed and the space charge heating disappeared. The beam temperature changed from 3 K to 0.3 K.

[1] Noda A, Ikegami M, Shirai T, *New J. Physics*, **8**, 288 (2006).

Real-time Observation of Laser Produced Ions

Recently there are many reports of high energy ions produced by intense ultra-short-pulse lasers. For the production of energetic ions by irradiating an intense laser on a foil target, the optimization of the various conditions is required. So far the energy spectrum of ions has been detected by a solid-state track detector so-called CR-39. The data analysis with the CR-39, however needs a longer time. Therefore, the real-time adjustment of the experimental parameters has been difficult.

The energy of ions can be obtained by the time-of-flight (TOF) from the production target. We have succeeded to extract the TOF signals of protons under the backgrounds due to the high power laser using a plastic scintillation counter shielded by special filters. By using the TOF detector, the energy spectrum as shown in Figure 3, can be obtained with real time.

Figure 1. View of the electron cooler at S-LSR.

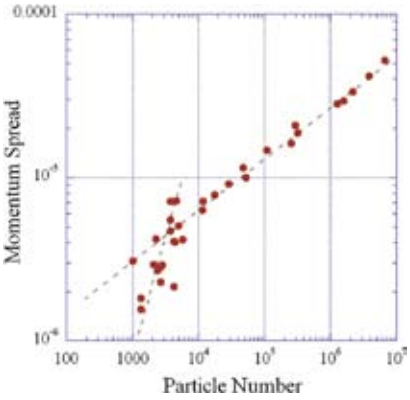

Figure 2. Dependence of momentum spread of protons on the particle number with the electron current of 25 mA at the cooler.

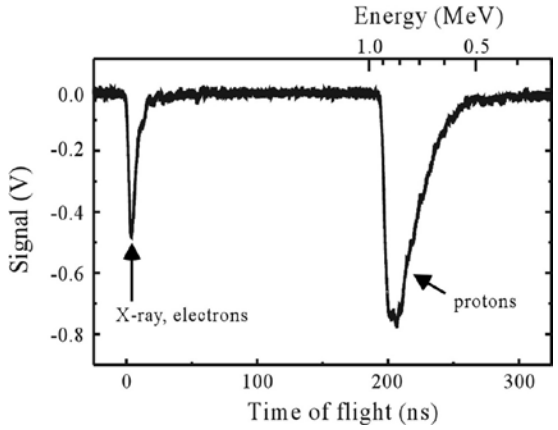

Figure 3. Typical TOF signal of protons obtained by photomultiplier. The protons are produced by a Ti:sapphire laser system called JLITE-X at JAEA Kansai Photon Science Institute.

Noda A, Design of Accelerator Systems for Compact On-site Neutron Sources, Synthetic Support Project for Accelerator Science, 8 July 2005–31 March 2006.

Iwashita Y, Research of Problems with High-Gradient Field ILC Superconducting rf Cavity, Joint Development Research at High Energy Accelerator Research Organization (KEK), 1 April 2005–31 March 2006.

Iwashita Y, Application and Development of Super Strong Permanent Magnet Especially for Linear Collider and Neutron Optics, Grant-in-Aid for Scientific Research, (A) (1), 1 April 2006–31 March 2009.

Award

Fadil H, PASJ Award for Young Scientists, Proof of Electron Cooling of Hot Ion Beams, Particle Accelerator Society of Japan, 4 August 2006.